Critical Structural Design Issues of the ECRH Upper Launcher for ITER

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The upper port positions for the EC wave launching system on ITER are reserved to stabilise the Neoclassical Tearing Modes (NTM) at the q=3/2 and q=2/1 surfaces by inducing off-axis current drive [1]. Resulting from the work of the "ECHULA group" of EU associations (ENEA/CNR Milano, CRPP Lausanne, FZK Karlsruhe, FOM Rijnhuizen, IPP/IPF Garching/Stuttgart) an initial reference design for the ECRH Upper Launcher was developed and transferred to the ITER design office in 2004 called the RS 3/8 launcher model. The required 20 MW mm-wave power injection was provided by 3 launcher units each with 8 remotely steered beamlines with fixed single fixed front mirrors. However, this configuration was becoming marginal for the steering ranges required for operation at different plasma scenarios (i.e. ITER plasma scenario 2, 3 and 5) because of adverse consequences for the focalisation of the beams, and therefore reduction of the local density of driven current. For this reason, advanced launcher variants have been developed since in which the mm-wave system was improved for higher stabilisation efficiency. The special challenge of the integration engineering was to ensure the feasibility of the advanced 'dogleg remote steering (RS)' [2] and front steering [3] microwave system within the boundaries and interfaces at ITER and to develop the basic concepts for the cooling and nuclear shielding design.

In this design development, a total of 10 critical structural issues have been identified, dealing mainly with the blanket shield module (BSM) design and cooling, but also with the launcher main structure and the internal shield. The different configurations of the mm-wave system for RS dogleg and FS launcher called for specific modifications of the structural components. In particular, the cut-out of the first wall panel, the size and positioning of front shielding elements inside the BSM, the internal shield and the closure plate must allow the preferred arrangement of the waveguides and the mirrors for the specific mm-wave system. Considering the space conditions inside the BSM, the most important aspect was the clearance between the beams and the top side of the flanges. This area was reserved for the cooling tubes to the BSM and the first wall panel (FWP). Otherwise this would have implied a severe revision of the reference cooling concept for the BSM. For the FS launcher, special shielding elements were set at the rear side of the first wall panel and at the bottom area of the BSM to provide additional shielding required by the steering mechanism of the mirrors. The temperature distribution of the blanket shield module housing caused by nuclear heating and plasma radiation was investigated on the grounds of the RS 3/8 launcher model. It was proven that during typical ITER burn cycles, no critical stress levels have to be expected neither for the steady state nor for the transient loading case. The launcher main structure with the double-wall was left unchanged as for the RS 3/8 launcher, thus cooling and baking are straightforward. The axial assembly - disassembly scheme of launcher internals could also be maintained. In conclusion, the integration engineering showed that structural design issues are essentially generic for the actual variants of the RS and FS launcher systems.

[1] H. Zohm et al., Journal of Physics: Conference Series 25 (2005), pp. 234-242
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